The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

REC'D 06 JUL 2004
WIPO PCT

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 22 June 2004

Patents Form 1/77

Patents Act 1977
(Rule 16)

1/77

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1.	Your reference	ID009-UK
2.	Patent application number *(The Patent Office will fill in this part)*	0310088.0
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)* Patents ADP number *(if you know it)* If the applicant is a corporate body, give the country/state of its incorporation	George Alan LIMPKIN 22 Hayes Mead Ciltern Park Berkhamstead Hertfordshire HP14 1BU, UK 6438206002
4.	Title of the invention	APPARATUS FOR SUPPLYING POWER TO A LOAD
5.	Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* Patents ADP number *(if you know it)*	Cole, Paul Gilbert Lucas & Co. 135 Westhall Road Warlingham Surrey CR6 9HJ 05815709001
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country / Priority application number *(if you know it)* / Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application / Date of filing *(day / month / year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	Yes

Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	17
Claim *(s)*	3
Abstract	1
Drawing *(s)*	14 only Uk

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	1 + 2
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Paul Cole

Date 1 May 03

12. Name and daytime telephone number of person to contact in the United Kingdom

Paul Cole - 01883 626211

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

APPARATUS FOR SUPPLYING POWER TO A LOAD

FIELD OF THE INVENTION

The present invention relates to electrical power transmission apparatus based on two-part magnetic connectors for at least partly replacing lighting and power supply circuits in buildings such as houses and flats, offices, school and university buildings, commercial buildings and the like, as well as for outdoor situations such as outdoor lanterns and garden lighting. It also relates to a two-part magnetic connector for use in the above apparatus, to individual primary and secondary portions of said connector, and to lamps having built-in secondary portions of a connector as aforesaid. The invention is particularly, though not exclusively, applicable to low voltage lighting (voltage < 50V) or fluorescent lighting, although the use of loads in a power as opposed to a lighting circuit is also envisaged, such loads being e.g. an electric motor, a power supply for a computer, radio, television or like electronic device, a heater or the like.

BACKGROUND TO THE INVENTION

Building power supply has up to now mainly used wiring that makes a direct metal-to-metal contact with terminals of the load, e.g. by plug and socket connectors of various types. In the UK, wiring regulations are governed by BS 7671 "Requirements for electrical installations" and IEC Publication 364 "Electrical installation of buildings". The electrical supply is typically divided into different circuits with different current ratings from 6 amps for lighting circuits serving ceiling roses and lampholders to 13 amps for appliances served via socket outlets (normally. 3-pin plugs according to BS 1363) and up to 40 amps for a cooker or electric shower unit. Power sockets are supplied by established suppliers such as MK Electric and screw and bayonet-type lighting sockets are widely available.

More recently, low voltage lighting has come into use, e.g. for recessed downlights based on dichroic lamps operating at 12V via a transformer, and similar surface-mounted spotlights and track or wire-based lighting systems. Such lighting still requires direct electrical contact with terminals of the load.

GB-A-0392052 (Siemens) discloses a two-part magnetic connector for use in a location having an atmosphere contaminated with fire-damp or other explosive gas. Transmission from a mains supply to a load is effected inductively using a casing having mains and load portions each enclosing a respective half of a ring magnetic core wound with a primary (mains) or secondary (load) winding. How the portions of the casing fit together is not explained in detail, but it is apparent from the drawing that the inner surface of the load portion is formed with a recess that is a push fit onto an external recess of the mains portion. When the load is removed, a keeper fits across the limbs of the mains half-core to avoid excessive current flowing through the primary winding that could otherwise overheat and burn out. GB-A-1366134 is concerned with lighting fittings in hazardous atmospheres and discloses a similar two-part connector in which the primary winding is connected in an L-C circuit that when under load is tuned to the frequency of a supply (e.g. 1 kHz) but which becomes de-tuned on separation of the parts. In one embodiment the core parts meet face-to-face and in another embodiment the load part fits coaxially into the core part. US-A-3995209 is similar and is concerned with connectors for use in communications systems. US-A-4303902 is also generally similar but discloses the use of ferrite cores and transmission frequencies of e.g. 100 kHz but does not disclose transmission of power for load devices as opposed to electrical signals e.g. for communications purposes at such frequencies and is devoid of detail as to power supply. The inductive couplers that it describes are intended for use where the ambient medium dictates against normal exposed metal-to-metal contact, e.g. for avoiding sparks in explosive atmospheres, for use in the off-shore industry, or for underwater applications, see also GB-A-2020116 which concerns a coupler for underwater use and US-A-4538863 which discloses couplers for underwater electric power lines.

SUMMARY OF THE INVENTION

The invention is based on the realization that with modern electronic high frequency power supplies it has become feasible to use a two-part magnetic coupling to provide power transmission to a load, provided that the core material of the transformer is resistive to avoid eddy currents and is low loss to avoid overheating at the frequencies used, and that over-current problems under no-load conditions are not so severe at the higher frequencies used where the primary winding on the first half-core provides a reactance, and where the power supply has built-in over-current and/or load short protection. In particular, the combination of a high frequency power supply with a two-part coupling having a resistive core material is believed to be new. Frequencies which are envisaged are above 23 kHz, e.g. 23-100 kHz, more preferably 25-60 kHz and usually 30-50kHz.

In one aspect the invention provides apparatus for supplying power to a load, comprising:

a power supply unit having an input for receiving current at mains frequency, means for converting said power at mains frequency to power at a frequency above mains frequency and an output for delivering power at the higher frequency; and

a two part magnetic connector having a first core portion that has a primary winding connected to the output of the power supply unit and a mating second core portion that has a secondary winding for delivery of power to a load, the core portions being of a high resistivity material.

The invention also provides a two-part magnetic connector, or primary or secondary portions thereof, for use in apparatus as aforesaid. The aforesaid connector may be provided with interengageable formations for establishing a mechanical as well as a magnetic connection between the two parts and preferably for holding said parts in relative attitudes such that pole pieces of said primary and secondary portions coincide. The primary and secondary portions of the connector

are desirably held positively together by clips or other resilient means with a minimal air gap or with a thin separating membrane of plastics or other electically insulating material. The portions of the two part magnetic connector may comprise pins and sockets that removably push together for mating the parts of the connector. Alternatively they may comprise clips and recesses that removably snap together for mating the parts of the connector. In a futher alternative, they may comprise bayonnet formations and recesses that removably twist together for mating the parts of the connector. Desirably the core material is of a low-loss ferrite that avoids eddy currents and does not become unduly heated at the relatively high frequencies at which power is transmitted.

The invention also provides an electrical load having in a proximal region thereof a half-core of a two-part magnetic connector and a secondary winding on the half-core for energising the load. A particularly preferred load is a low-voltage incandescent lamp or a fluorescent tube having in its base a half-core of a magnetic connector as aforesaid and a secondary winding for energising the lamp or tube with received power.

The invention provides a coupling link between a high frequency AC power source that is connected to a primary winding of a transformer and a load that is connected to a secondary winding of the same transformer. The transformer can be separated into two parts that permit the connection between a load of any type and the power source for electrical supply applications. However, the connection system does not generate any voltage or current and is therefore inherently safe in a wide range of environments. One principal use of the coupling technology is in the field of lighting, but other uses e.g. in power circuits are also within the scope of the invention.

As previously explained, various forms of mechanical connection are envisaged to hold the two parts of the coupling positively together.

BRIEF DESCRIPTION OF THE DRAWINGS

How the invention may be put into effect will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 shows a basic configuration of a mains supply driving a load vai a high frequency supply unit and a two-part magnetic coupler;

Fig 2a is a diagram of a high frequency coupler that may be used for low voltage lighting Fig. 2b is a diagram of the output waveform, Fig 2c is a block diagram of the unit and Fig. 2d is a more detailed circuit diagram;

Fig. 3a is a diagram of an electronic ballast unit and Fig 3b is a diagram of the output waveform;

Fig 4 is a detail of the two-part coupling;

Fig 5 is a block diagram of a configuration for low voltage lamps;

Fig. 6a is a block diagram of a configuration for driving a discharge tube and Fig 6b is a more detailed circuit diagram;

Fig 7a is a block diagram of a configuration for driving a LED lamp, and Figs 7b, 7c show possible output waveforms;

Fig 8 is a block diagram of a wire loop system;

Fig. 9 is a block diagram of a low voltage lamp used as a downlight;

Fig. 10 is a block diagram of a system using two magnetic couplers and a linking cable;

Fig 11 is a block diagram of a lighting system in which lamps are powered by individual associated power supply units, Fig 12 is a block diagram of lamps drived in series from a single power supply unit, and Fig 13 is a block diagram of lamps driven in parallel from a single power supply unit;

Fig 14 a is an exploded view of a LED-based downlight and connector, Fig 14b is an exploded view of the connector moiety, Fig 14c is a diagrammatic view of the lamp moiety, Fig 14d is a detail of the lamp and half-core and Fig 14d is a diagrammatic view of a downlight-type housing to which the aforesaid components may be fitted;

Fig. 15 is an exploded view of a fluorescent lamp, ceiling socket or rose and primary-side half-core;

Figs. 16a and 16b are perspective views of the undersurface and the upper surface of a power supply unit for fitting to the lamp unit of Fig. 15;

Figs. 17a, 17b are perspective views of the upper portions and the lower portions of a plug for transmitting power to a load, Fig. 17c shows the plug being mated to a complementary socket, and Fig 17d is an exploded view of the plug;

Fig 18a is a perspective view of a multi-output parallel transformer and a coupler for connecting a load to the transformer, and G Fig 18b is a diagram showing a range of potential products of this type.

Fig 19 shows a two-part magnetic connector in which the parts fit together bayonet-wise;.

Fig. 20 shows a fluorescent lamp having a moiety of a two-part connector and associated driving circuitry built into its proximal end; and

Fig. 21 shows a pair of fluorescent lamps together with a track having points at which the lamps may be driven.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In Fig. 1, which shows a basic configuration of a power supply arrangement according to the invention, a mains AC power supply 100 at e.g. 110 or 240 V and 50-60 Hz supplies power to a high frequency AC to AC power supply unit 102 which feeds a primary winding 104 on half-core 106 of a split transformer 108. A secondary winding 110 on half-core 112 is connected to load 114. Examples of loads that might receive power from the above supply include low voltage halogen lamps, other low voltage incandescent lamps, fluorescent lamps, fans, electric motors, detectors or power distribution circuits e.g. for use in a building or part of a building or for use in outdoor lighting. The contact may be established by mating the two parts, and may be broken by separating them, the parts being relatively movable as indicated by the arrows 116.

Fig 2a shows diagrammatically a high frequency low voltage supply in which power from supply 200 is fed to high frequency low voltage AC-AC power supply unit 202, again at 110 or 240V and 50-60 Hz and produces at 204 a nominal 11 volts AC waveform. As seen in Fig. 2b, the waveform may have e.g. a nominal 11.7 volts RMS and may comprise an AC waveform of frequency 23-100 KHz, preferably 23-60 KHz which modulates a lower frequency envelope e.g. of frequency 100 Hz (50 Hz input) or 120 Hz (60 Hz input) this power supply arrangement being suitable e.g. for incandescent lighting. Low voltage halogen lamps have the advantages of brilliance and long life and are normally rated from 5 to 50 W drawing 0.4A to 4A at 12 Volts. They may be supplied in capsule or dichroic form and may be used as spotlights for installation on a string or rail or as downlights for fitting to or within a ceiling.

The fundamental components of a switch mode power supply are shown in Fig. 2c. Power from supply 200 passes to a power supply unit 202 having a mains filter stage 203 for suppressing mains interference flowing from the mains supply to the unit 202 and also from the unit 202 back into the mains. The filtered mains power passes to diode bridge rectifier 205 from which a rectified output at 100 or 120 Hz depending on the supply frequency passes to a modulator 207 which modulates the envelope to produce AC at a frequency of 23-100 kHz, preferably 23-60kHz and most preferably about 30-50 kHz to give the waveform of Fig. 2b. The modulated signal passes to output stage 209 which supplies a 12 or 24 volt high-frequency modulated 100 or 120 Hz AC output at 204 to primary winding 211 of half-transformer 213. That half-transformer mates with half-transformer 217 having secondary winding 215 that provides power to incandescent lamp 219.

A simplified circuit for a practical power supply is shown in Fig. 2d. An AC voltage is supplied to a full-bridge rectifier D_1-D_4 with a mains filter provided by capacitors C_1-C_3 and a ferrite choke HFC. The filtered mains current provides an envelope waveform that is modulated using a half-bridge circuit provided by transistors Q_1, Q_2 that conduct alternately and by capacitors C_5, C_6. The primary of output transformer T_2 is connected across the half-bridge and an L-C self-oscillating circuit is provided by primary Tic of feedback transformer T_1 that is connected in series with the primary of T_2. Opposite-sense secondary windings T_{1b}, T_{1a} provide excitation to the bases of transistors Q_1, Q_2 via resistors R_1, R_2 and switching capacitors C_7, C_8. Zener diodes D_5, D_6 with reverse voltages provide protection for the bases of Q_1,Q_2, and diodes D_7 and D_8 provide protection for the transistors Q_1 and Q_2 against reverse current. A starter circuit timed by network R_3,C_9 and controlled by the DIAC shown is connected to the base of Q_2 . The secondary of T_2 provides the required voltage reduction for lamp 219 and may be arranged to provide an output power of about 60 VA for driving a single lamp 219 or e.g. 200 VA for driving a plurality of lamps via a lighting track or the like. To avoid excessive current loads, e.g. if the lamp 219 becomes open-circuit, a predetermined increase in the voltage drop across resistor R_4 which measures the

current being drawn by transistors Q_1, Q_2 provides an activating signal via resistors R_5, R_6 to the base of transistor Q_3 which is biased normally OFF by resistor R_7 to switch it ON so that capacitor C_9 is shorted and oscillation of the half-bridge ceases. A recovery time is defined by the time constant of R_5, C_{10} connected in the base circuit of Q3. In addition to this electronically-switched current overload protection, there may be provided thermal protection provided by a cut-out monitoring the temperature e.g. of the output transformer T_2 or a winding thereof. It will be appreciated that all the circuits described above are contained in the unit 202 which is believed to be representative of devices on the market based on discrete components and bipolar transistors.

Switching mode power supplies are extensively described in the patent literature, and the technology described in such references may be applied to the invention. A circuit that can provide a constant voltage or a constant current output is disclosed in US-A-3538518 (Allington, Instrument Specialities Company) and further designs for switched mode power supplies are described in e.g. US-A-4453205 (Voight) and 4945465 (Marinus, Philips), Over-current control and/or overload protection are discussed in e.g. US-A-4713740 (Drabing, SMS Advanced Power), 4916569 (onopka, Zenith Electronics), 4858094 (Barlage, Allied-Signal), 4916 US-A-5633787 (Song, Samsung), 6434023 (Preller, Infineon Technologies), 2001/0009517 (Preller), 2001/0019469 (Koh, Thomson Multimedia), and 2002/0105767 and (Schuellein, Semiconductor Components). The latter specification reviews over-current protection schemes in detail including

(a) pulse-by-pulse schemes that clamps the peak of the power supply output current when a sensed current magnitude exceeds a threshold current magnitude, and inhibits the power supply output by reducing the duty cycle of a power switching device,

(b) a hiccup current limit scheme which terminates power supply operation once an over-current condition is detected and attempts restart after a predetermined time period

(c) a foldback current limit scheme which causes the power supply maximum current limit to decrease with power supply output voltage so that if the supply output voltage decreases due to an overload or short circuit, the maximum current limit also decreases so that the output current is reduced to a safe level and

(d) a latch-off protection scheme in which the power supply is completely shut down under an over-current condition and normal operation can only be restored by cycling the input voltage (ON/OFF) or toggling an ENABLE input. As previously explained, thermal protection against over-temperature is also commonly provided. The above schemes can, of course, be used in a power supply unit of the invention. A high-frequency low-cost power supply for driving 12 Volt halogen lamps is disclosed in US-A-6208086 (Nerone, General Electric Company).

Electronic transformers that are currently available in the UK for low voltage halogen lamps include e.g. the Leax LT 60 (20-60 Watts) and PD 250 (100-250 Watts), see http://www.leax.co.uk/PDF/electronic%20transformers.pdf. Suitable HF power supplies are also available from Arlen-EFA of Slough, UK (see their TRX-105 LV transformer having a load range of 20-105 VA, short circuit protection and overload protection), Tridonic.Limited, Basingstoke, UK (TE isolating transformers also providing 20-105VA, having overload, overheating and short-circuit protection, and operating a lamp at 30-40 kHz; also HF ballasts, LED power supplies and discharge drivers), Osram (105VA 12V transformers, also HF ballasts, LED power supplies and discharge drivers), and products from Black Box (LV transformer), Mode (LV transformer), Universal Light & Power (LV transformers), Multiload (VoltMaster LV transformers), Huco (LV transformers), Philips (HF ballast, LED power supplies and discharge drivers), Magnatech (HF ballast), Helvar (HF ballast, discharge driver), Transfiltala (LV transformer) and Kaoyi (JP).

The core of two-part transformer T_3 is preferably a soft magnetic metallic oxide-based ceramic or soft ferrite. Ferrite materials may be divided into three groups:

(a) Manganese-zinc ferrites $(Mn, Zn)O.Fe_2O_3$ which group is designated as H-materials, are of resistivity 10^1-10^3 Ωcm and is less preferred;

(b) Nickel-zinc ferrites $(Ni, Zn)O.Fe_2O_3$ which group is designated as N-materials and which may have specific resistivities of more than 10^3 Ωcm, typically 10^4-10^7 Ωcm., and e.g. 10^4-10^5 Ωcm..

(c) Magnesium-zinc ferrites $(Mg, Mn, Zn)O.Fe_2O_3$ which group is designated as HR-materials. Ferrites may also contain small amounts of Co, Ti, Ca, Si etc to obtain particular desired properties. The ferrite may be a Mn-Zn ferrite but is preferably a Ni-Zn ferrite on account of higher intrinsic resistivity and low core loss, suitable grades being N27 and N67.

For fluorescent lamps, a high frequency AC-AC supply is used. The power supply shown in Fig. 3a is similar, with mains supply 300, supply unit 302 and output 304, but in this instance the output has a RMS voltage of 240V at a frequency of 23-100 kHz and with a ripple frequency of e.g. 100 Hz. In the past, conventional fluorescent lighting systems have been operated from the mains using a series choke as ballast for creating sufficient voltage to operate the lamp and a glow starter to start the lamp and to limit the lamp current after it has started. Although such a system is low cost, it suffers the disadvantages of audible hum, loss in the choke, delay in ignition and flicker. Use of electronic ballast to energise the lamp involves rectification of the mains current to a DC voltage which is then inverted to a high frequency AC voltage for driving the lamp. Electronic ballast operates at a frequency of typically 20-60 kHz and the higher operating frequency improves efficiency by about 10% because of an increase in phosphor excitation, eliminates flicker, improves speed of ignition and extends lamp lifetime. Electronic ballasts also consume less power than magnetic chokes and using switch mode techniques the combined energy saving can be about 25% with the same light output and with reduction in size of the driving electronics. The high

frequency AC from an electronic ballast can also be used with the above mentioned switch mode techniques and with an two-part coupling transformer based on ferrite half-cores. Switched mode power supplies for fluorescent lamps are disclosed, for example, in US-A-5065074 (Hesketh, Coolite), 5359274 (Bandel, Philips), 5796597 (Fitzgerald, Thomson), 6100647 and (Giannopoulos, Philips).

Fig 4 is a detail of the split transformer with a supply side or socket winding 104 having turns Nt and an output or plug side winding having turns Nt. For step up Vout, Nt/Mt > 1 whereas for step down Vout, Nt/Mt < 1. Thus in the example of Fig 5, components 500-512 correspond to those previously described, Mt is for example four turns, Nt is four turns also to deliver an output RMS of 12 V to low voltage lamp 514 and Nt is 8 turns to deliver 24V to the lamp. In the example of Fig 6, components 600-612 correspond to those previously described, Mt is for example 91 turns, Nt is also 91 turns also to deliver an output RMS to a lamp circuit. One side of secondary winding 610 is connected to ballast inductance 612 in series with one electrode of fluorescent lamp 616 and is series connected via series capacitors 616, 618 and bridging variable resistor 620 (620; Rv = PTC) to the other electrode of the lamp 616 which in turn is connected to the other side of secondary winding 610. A more detailed circuit is shown in Fig 6b, which is similar to Fig. 2d except that electrolytic capacitor C_{11} is connected between one side of the rectifier and the negative rail, the output transformer T_2 is deleted and the primary of the two-part transformer is connected across the half bridge in series with feedback coil T_{1c}.

In the further example of Fig 7, components 700-712 correspond to those previously described, and winding 710 is connected across HF diodes D1-D4 connected as a bridge rectifier 714 that supplies DC power via series resistor 716 and optional HF capacitor 720 to light-emitting diode 718. The output of the supply unit 702 may be a HF modulated DC as at Fig 7b or a HF DC as at Fig. 7c.

Wire loop systems are shown in Figs 8 and 9. In Fig. 8 the parts 800-814 are as previously described and the primary winding 804 is at an arbitrary location on a single wire loop 803. Power from supply 800 to the load 814 can be established without cutting any wires or piercing the insulation layer thereof. In Fig 9 the wire loop 903 and the socket-half 904, 906 of the present connector form part of lighting wiring built into a building. Plug parts 910,912 form part of a light fitting 916 built into a ceiling of the building and the light fitting has a conventional socket 918 for a conventional low voltage incandescent lamp 920 which provides the load 914 generally indicated in this instance by an arrow. The required connection can be established without using terminal blocks or cut wires, which reduces the skill required to fix the fitting 916 in position.

In Fig 10, a mains supply 1000 feeds high frequency power supply unit 1002 which outputs into a first two-part connector 1004a, 1010a connected by cable 1007 to second two-part connector 1004b, 1010b which in turn is connected to load 1014, thereby providing an indirect connection between the power supply 1002 and the load 1014.

Various possibilities for providing lighting units with the two-part conductive connectors described above are shown in Figs. 11-13. In Fig. 11, mains supplies 1100a-1100d provide power to individual power supply units 1102a-1102d connected by respective two-part connectors 1106a-1106d, 1112a-1112d to loads 1114a-1114d in the form of lighting units. Installation of the system requires no cut wires and simply relies on loops of wire through the ceiling. No terminal blocks need be used, and the individual lighting units are easy to install and replace. In Fig 12, a mains supply 1200 feeds supply unit 1202 having a ring providing power to series arranged connectors 1204a-1204c, 1210a, 1210c connected to respective loads 1214a-1214c ($1<c<n$). The arrangement of Fig. 13 is similar except that the connectors 1304a-1304n, 1310a-1310n are connected to the unit 1303 in parallel.

The present invention can provide electrical wiring for a building in which, for example in a lighting circuit the overall number of screw-in or push-in terminations can be reduced. Most electrical fires start in cables or terminations owing to breaks and arcing. The greater the number of terminations, the greater the risk of fire or electric shock. Furthermore, making terminations is the most time-consuming and hence costly part of any electrical installation, requiring skilled labour. The fewer the number of terminations, the fewer the mistakes that can be made. Lighting installations are particularly difficylt and time consuming because the outlet has to be installed in a ceiling at height, upside-down and against gravity. Several connections are required: a live earth neutral, a switched live and often a permanent live. Low voltage installations require transformers and greater current and risk of arcing. In addition to electrical connections, mechanical fixings are required and the weight of the luminaire has to be supported while connections are being made.

Use of a two-part magnetic connector to provide power connections to a LED-based lighting installation is shown in Figs 14a-14f. A lampholder body 1401 of polycarbonate or other electrically insulating plastics material is provided with a top opening for receiving a ferrite half-core1403 carrying a primary winding 1404, and has fixing flanges and depending clips 1407. A lamp holder 1409 has a die-cast aluminium reflector 1411 attached to a polycarbonate rear housing 1413 in which is fixed a complementary second ferrite half-core 1415. Upwardly facing latch tongue 1417 can be demountably engaged into the clips 1407 to fasten the lamp holder in position. The lamp holder 1409 also supports a LED lamp such as a Luxeon LEDwhich can receive power via secondary winding 1420 on half-core 1415. The snap engagement of tongue 1417 between clips 1407 and resilience of the materials used enables the half-cores 1403, 1415 to be urged positively into face-to-face contact, minimising the air gaps between them and consequential power losses. An OEM-manufactured housing 1422 is designed to be recessed into a ceiling and has a top face 1424 formed with an aperture 1426 through which the extremities of primary half-core 1403 depend and into which tongue 1417 of the

lamp holder 1409 can be inserted for engagement with the clips 1407. The flanges 1405 of the body 1401 are attached to the flanges 1405 by bolts or studs (not shown). Power for the primary winding 1404 comes from HF transformer 1430 connected to mains supply and having an output wire loop 1432 that can be wound onto the half-core 1403 to provide the primary winding. It will be appreciated that an incandescent lamp, e.g. a low-voltage dichroic lamp may be used in place of the LED.

An installation for a fluorescent lamp working at mains voltage is shown at Fig. 15. Tubes 1500 depend from a body 1502 housing the ballast and starting circuitry shown in Fig 6 on a small circuit board and having a secondary winding around a load half-core 1504 which appears at a top face of the body 1502. A ceiling rose 1506 has depending walls 1508 between which the body 1502 is a sliding fit, and latch tongues 1510 also depending from the rose 1506 slide over recessed surfaces 1512 of the body and snap engage locking surfaces 1514 to hold the body 1502 positively into the rose 1505. A second half-core 1516 around which is wound primary winding loop 1518 is a sliding fit between upstanding walls 1520, 1522 and is retained in position by snap engagement of clips 1524. Again the use of resilient clips enables the half-cores 1504, 1516 to be urged positively together in face-to-face contact. In Figs 16a, 16b, there is shown a power supply unit 1602 fed with mains current via a supply cable 1600and having a circuit e.g. as shown in Fig. 6b. From the underside of the unit 1602 there appear pole pieces of a half core 1616 arranged to clip into the socket defined by walls 1520,1522 of the rose 1506. Latching surfaces on the pole pieces 1616 enable the power unit to be clipped into the socket in either the vertical attitude of Fig. 16a or the horizontal attitude of Fig. 16b.

In Figs 17a-17d, a plug and socket connector for a load which may be a lamp or other electrical device has a load supply cable 1700 leading to a plug body 1702 having first and second pole-pieces 1704, 1706 of a magnetic half-core and on opposite edges of the body 1702 first and second forwardly or downwardly

protuberant clips 1708, 1710. The plug connector mates with a complementary socket portion 1712 fed with power using a unit e.g. as described with reference to Fig. 2d or Fig. 6b and protected if desired by a thin membrane of plastics or other suitable electrically insulating material.. As seen in Fig 17d, the plug body comprises upper and lower portions 1702a. 1702b that fasten together by screws 1713 and it encloses magnetic core 1714 wound with a secondary winding leading to cable-receiving terminals 1715. Although the present embodiment is based on clips that positively hold the mating components together so that the magnetic half-cores are held positively in contact to minimise air-gaps and consequent power losses, it may be sufficient to provide two or three plain pins protruding from the secondary or plug part for receiving in sockets in the primary or socket part. The pins and sockets may be of metal or plastics material but are electrically isolated and do not participate in the connection except, perhaps to provide an earth line for protecting the load.

Fig 18a shows a mains cable 1800 leading to a high frequency transformer or ballast unit 1802 having at one end first and second exposed pole pieces 1804, 1806 of a primary side half-core that take the form of in the form of rails. A plurality of sockets are formed above and below the rails 1804, 1806 at spaced intervals therealong. Plug connectors 1810 fit to the sockets in side by side relationship and contain half-cores that mate with the rails 1804, 1806, and first and second protuberant clips 1812, 1814 that snap into the sockets 1808. Secondary windings in the connectors 1810 lead to load cables 1816. Various configurations are shown in Fig 18b which is believed to be self-explanatory.

Fig 19 shows an appliance-mounted coupler 1900 that is a twist or bayonet fit to a BESA box 1902 for establishment of magnetic and mechanical connections therebetween.

Fig 20 shows a fluorescent lamp 2000 having a fluorescent tube 2002, a proximal region 2004 housing the circuitry for driving the lamp, first and second

pole pieces 2006 for establishing a power-transmitting magnetic connection to a socket and opposite first and second fastening members for establishing a mechanical connection between the lamp and the socket. The mechanical connection may take the form of clips that positively hold the lamp in place, a screw connection or bayonet projections, provided that the connections require the lamp to be fastened in place in the correct attitude for face-to-face contact between its pole pieces and those of the socket.. As apparent from Fig, 21 fluorescent lamps 2100, 2102 may be powered at socket locations 2106, 2106a spaced along a track 2104 that may house a high frequency electronic ballast unit of the kind shown in Fig. 6b and fed with mains power by cable 2108.

CLAIMS

1. Apparatus for supplying power to a load, comprising:

a power supply unit having an input for receiving current at mains frequency, means for converting said power at mains frequency to power at a frequency above mains frequency and an output for delivering power at the higher frequency; and

a two part magnetic connector having a first core portion that has a primary winding connected to the output of the power supply unit and a mating second core portion that has a secondary winding for delivery of power to a load, the core portions being of a high resistivity material.

2. The apparatus of claim 1, wherein the power supply unit is arranged to convert the power to a frequency of 23-100 kHz.

3. The apparatus of claim 1, wherein the power supply unit is arranged to convert the power to a frequency of 25-60 kHz.

4. The apparatus of claim 1, wherein the power supply unit is arranged to convert the power to a frequency of 30-50 kHz.

5. The apparatus of any preceding claim, wherein the power supply is an electronic transformer for delivering a modulated DC supply at a voltage less than 50V.

6. The apparatus of claim 5, wherein the power supply is an electronic transformer for delivering a modulated DC supply at a voltage of 12 or 24V.

7. The apparatus of claim 5 or 6, wherein the power supply has over-current and/or load short-circuit protection.

8. The apparatus of any of claims 5, 6 or 7, wherein the power supply is a switched mode power supply.

9. The apparatus of any of claims 1-4, wherein the power supply is an electronic ballast.

10. The apparatus of any preceding claim, wherein the first and second core portions of the magnetic connector are of a material having a bulk resistivity of at least 10^3 Ωcm.

11. The apparatus of claim 10, wherein the first and second core portions of the magnetic connector are of a material having a bulk resistivity of at least 10^4 Ωcm.

12. The apparatus of any preceding claim, wherein the first and second core portions are of a nickel-zinc ferrite.

13. The apparatus of any preceding claim, wherein the portions of the two part magnetic connector comprise pins and sockets that removably push together for mating the parts of the connector.

14. The apparatus of any of claims 1-12, wherein the portions of the two part magnetic connector comprise clips and recesses that removably snap together for mating the parts of the connector.

15. The apparatus of any of claims 1-12, wherein the portions of the two part magnetic connector comprise bayonnet formations and recesses that removably twist together for mating the parts of the connector.

16. The apparatus of any preceding claim, wherein the load comprises one or more mains incandescent lamps, low-voltage incandescent lamps, light-emitting diode lamps or fluorescent lamps.

17. The apparatus of any preceding claim, wherein the load comprises a plurality of lamps in parallel.

18. The apparatus of any preceding claim, wherein the load comprises a plurality of lamps in series.

19. The apparatus of any preceding claim, wherein the load comprises a plurality of lamps on a wire or track.

20. The apparatus of any of claims 1-15, wherein the load comprises an electric motor, a power supply for a computer, radio, television or like electronic device, a heater or the like.

21. A two-part magnetic connector, or a primary or secondary portion thereof for use in the apparatus of any preceding claim.

22. A lamp having in a proximal region thereof a half-core of a two-part magnetic connector and a secondary winding on the half-core for energising the lamp.

23. The lamp of claim 22 having in said proximal region a housing that supports an incandescent bulb or a fluorescent tube extends, said housing having at a surface at least first and second pole pieces of said core.

24. The lamp of any preceding claim, wherein the housing is formed with or carries fastening means for securing said lamp in a socket.

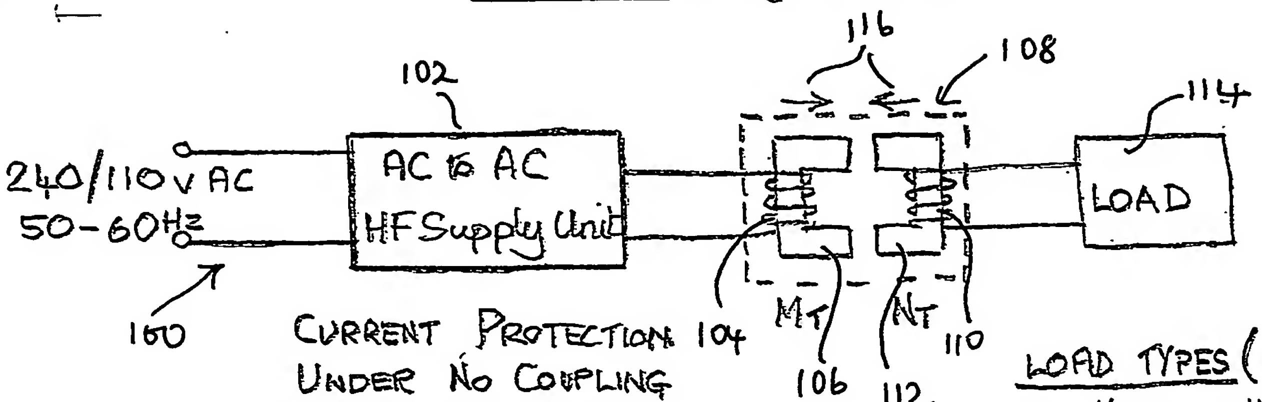
25. The lamp of any preceding claim, wherein said fastening means comprises bayonet formations, a screw formation or clips.

ABSTRACT

APPARATUS FOR SUPPLYING POWER TO A LOAD

Apparatus for supplying power to a load, comprises a power supply unit e.g. a switched mode electronic transformer or electronic ballast having an input for receiving current at mains frequency, means for converting said power at mains frequency to power at a frequency above mains frequency e.g. 30-50 kHz and an output for delivering power at the higher frequency. A two part magnetic connector has a first core portion that has a primary winding connected to the output of the power supply unit and a mating second core portion that has a secondary winding for delivery of power to a load, the core portions being of a high resistivity material, e.g. a ferrite having a resistivity of at least 10^4 Ωcm. The apparatus may be used to power e.g. low voltage halogen or other incandescent lightinng, fluorescent lighting, or an electric motor, a power supply for a computer, radio, television or like electronic device, a heater or the like.

Basic Configuration



CURRENT PROTECTION UNDER NO COUPLING OR NO LOAD CONTROL WITHIN POWER SUPPLY OR EXTERNALLY OPTION (HF = HIGH FREQUENCY)

FIG. 1

LOAD TYPES (HF)
- LOW VOLTAGE HALOGEN
- LOW VOLTAGE LAMPS
- FLUORESCENT LAMPS
- FANS
- MOTORS
- DETECTORS
- POWER DISTRIBUTION

AC to AC HF SUPPLIES

LOW VOLTAGE

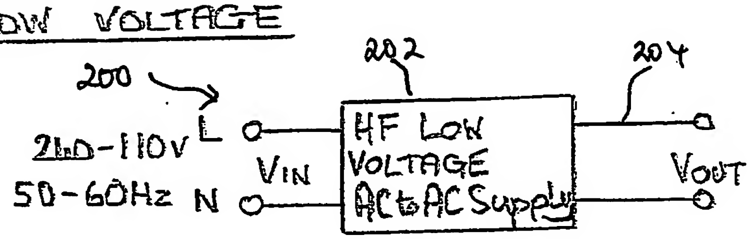
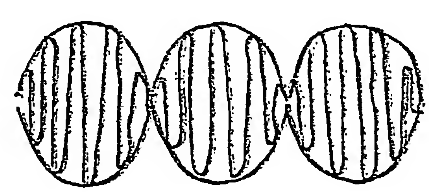


FIG 2a

FIG 2b



RMS 11·7 VOLTS
VOLTAGE WAVE FORM
100 Hz MODULATED WITH HIGH FREQUENCY 23KHz — 100KHz

FLUORESCENT

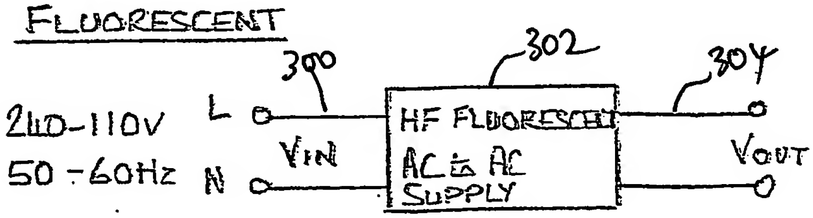
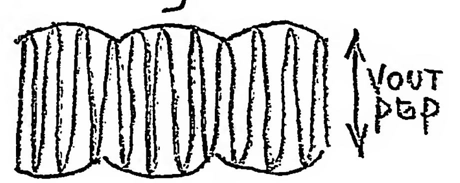
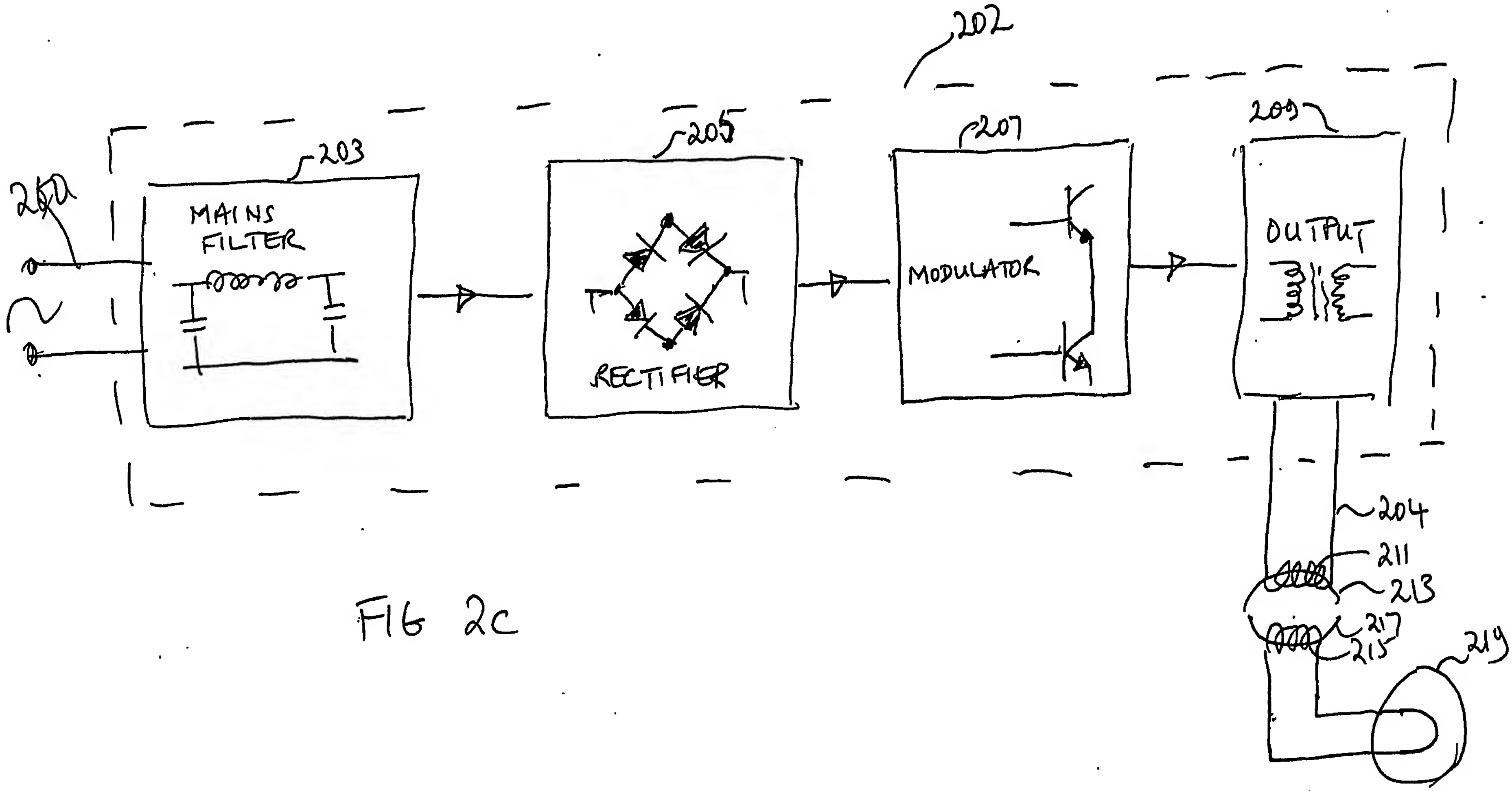


Fig 3a

Fig 3b



RMS 240V
VOLTAGE WAVE FORM
HF 23KHz - 100KHz
Ripple 100 Hz



202
203
MAINS FILTER
205
RECTIFIER
207
MODULATOR
209
OUTPUT
204
211
213
217
215
219

FIG 2c

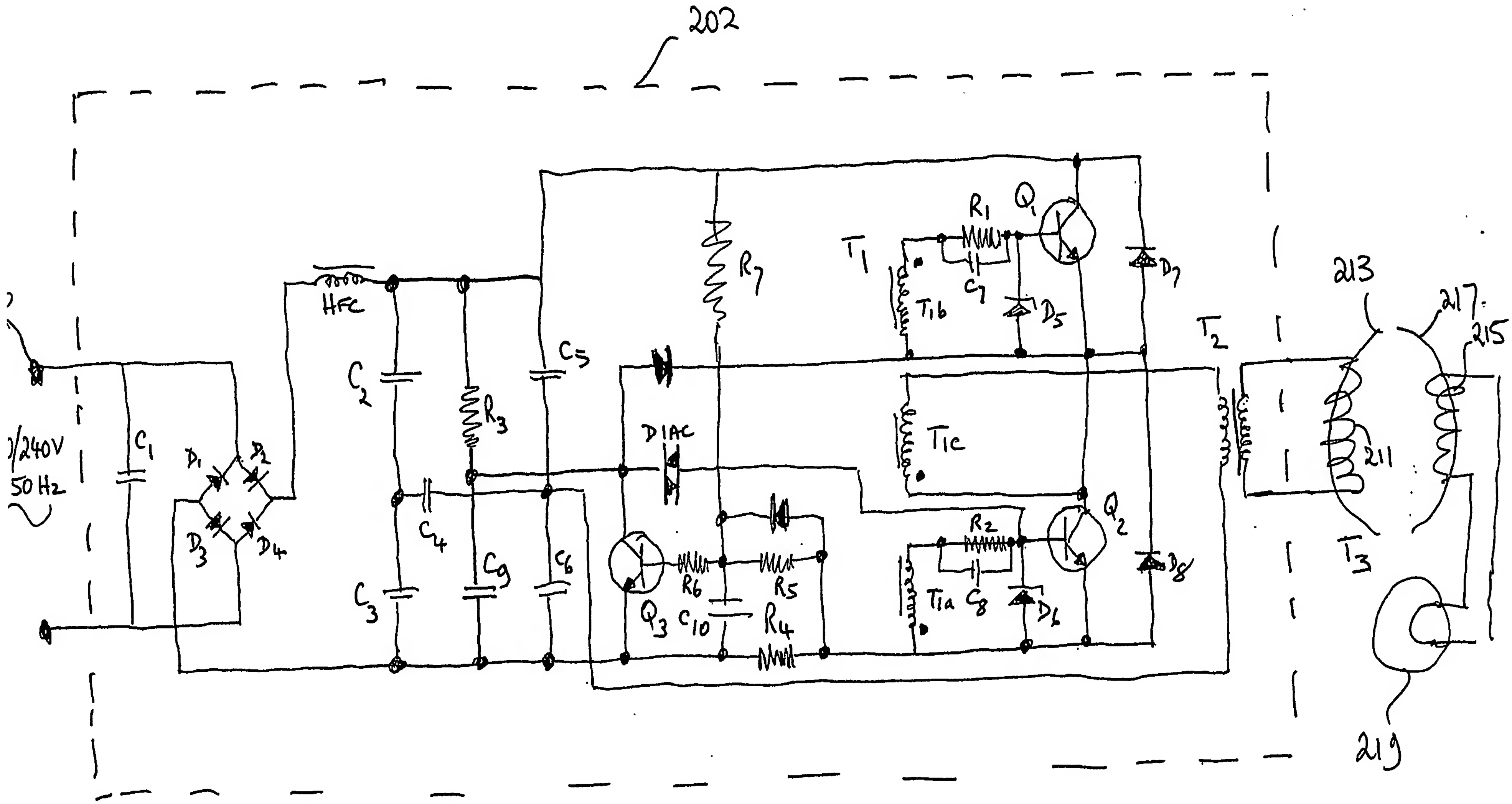
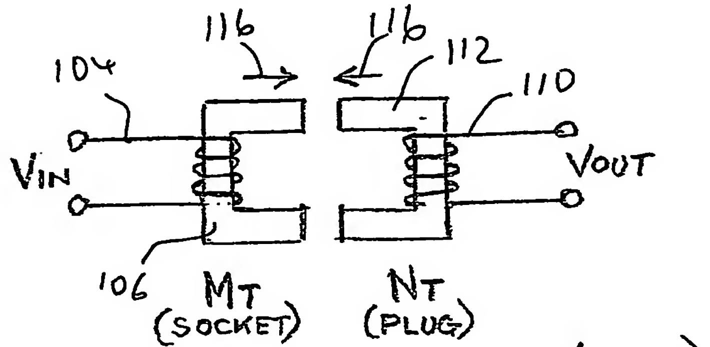

202
Q1
R1
T1
C7
T1b
D5
D7
R7
HFC
C5
T2
213
217
215
C2
R3
T1c
211
D1
D2
DIAC
C1
240V
50 Hz
C4
Q2
D3
D4
R2
Cg
C6
R6
R5
D8
T3
C3
Q3
C10
R4
T1a
C8
D6
219

Fig 2d.

Inductronic Connection Module



FERRITE MATERIAL
N27 or N67 or equiv:
ANY FERRITE SHAPE

VOLTAGE TRANSFER FUNCTION

$\frac{N_T}{M_T} > 1$ STEP UP (V_{OUT})

$\frac{N_T}{M_T} < 1$ STEP DOWN (V_{OUT})

Fig 4

LOAD CONFIGURATIONS

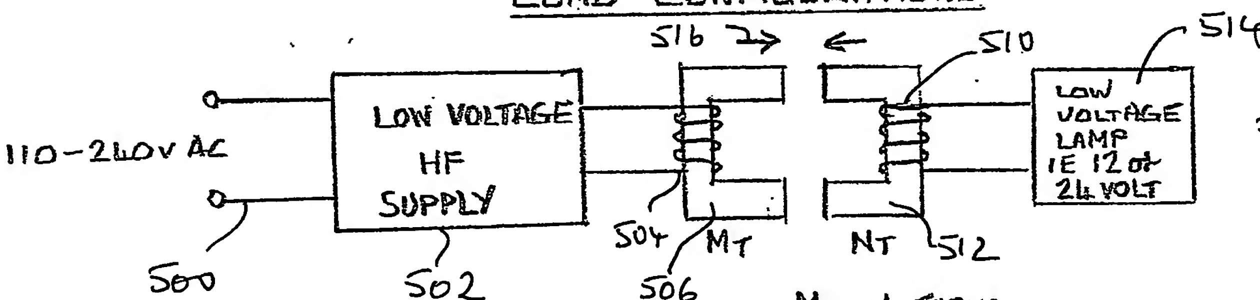


Fig 5

M_T = 4 TURNS
N_T = 4 TURNS (12V)
N_T = 8 TURNS (24V)

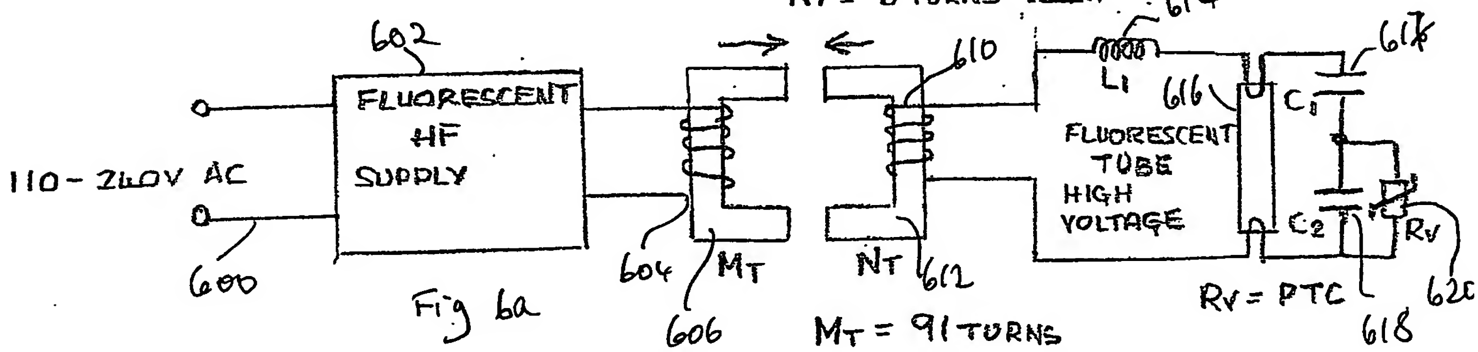


Fig 6a

M_T = 91 TURNS
N_T = 91 TURNS

Fig 7a

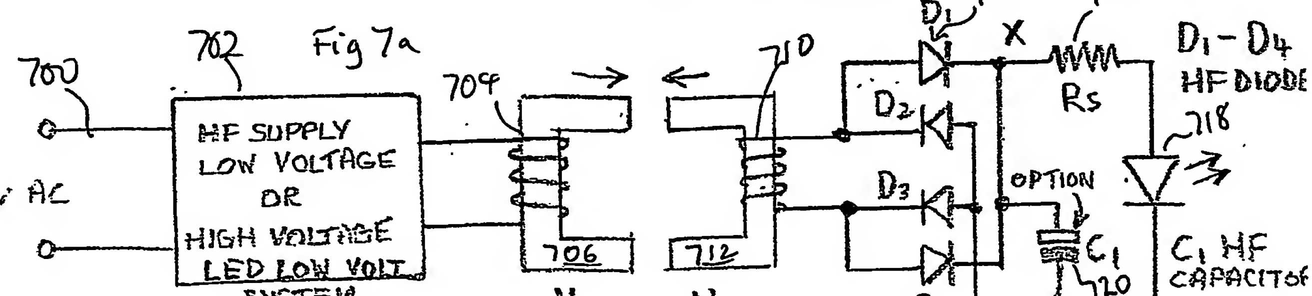


Fig 7b

OUTPUT MODULATED DC X

HF

LOW VOLTAGE LED LIGHT SOURCE

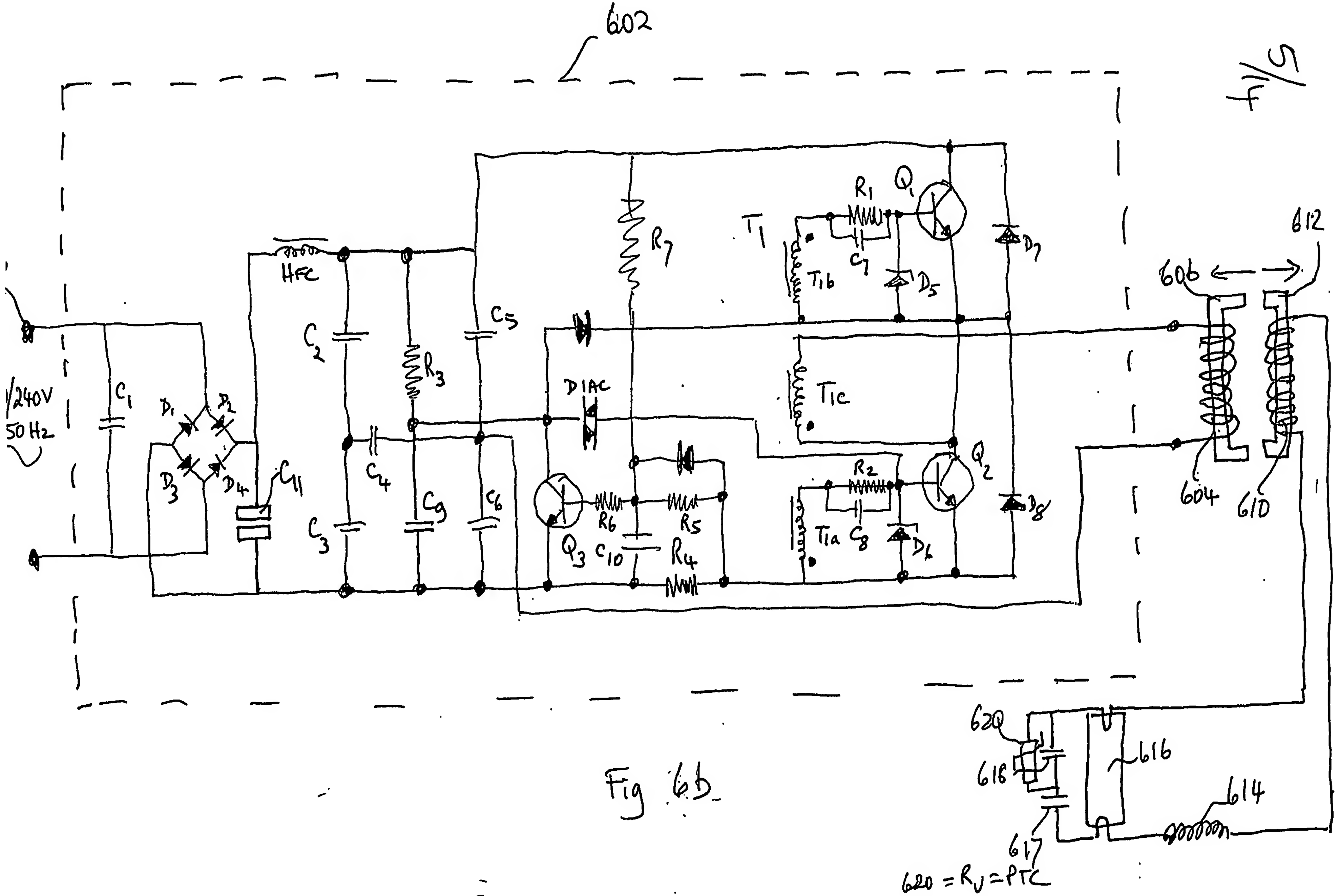

602
1/240V
50 Hz
C1
D1
D2
D3
D4
C11
HFC
C2
C3
C4
R3
C9
C5
C6
DIAC
Q3
R6
C10
R5
R4
R7
T1
R1
C7
Q1
T1b
D5
D7
T1c
R2
Q2
T1a
C8
D6
D8
606
612
604
610
620
618
616
614
617
620 = RV = PTC

Fig 6b

INDUCTRONIC SYSTEMS

WIRE LOOP SYSTEMS

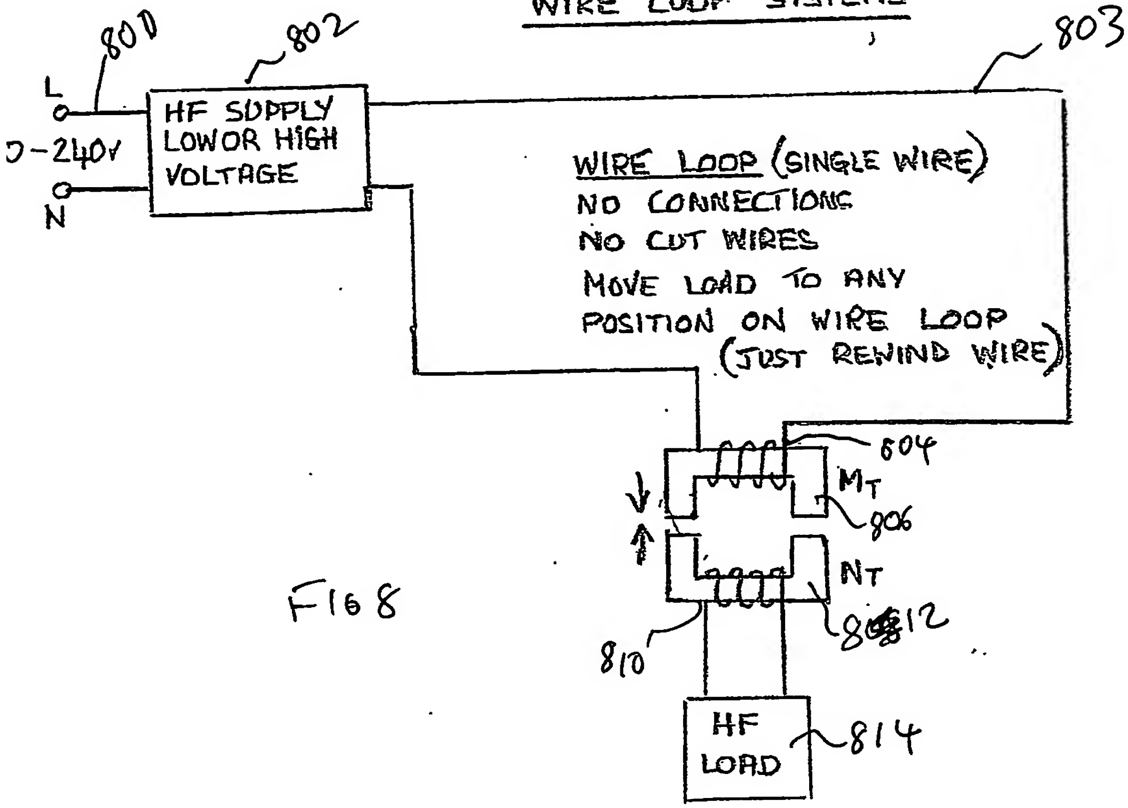


FIG 8

INDUCTRONIC LIGHTING PRODUCT

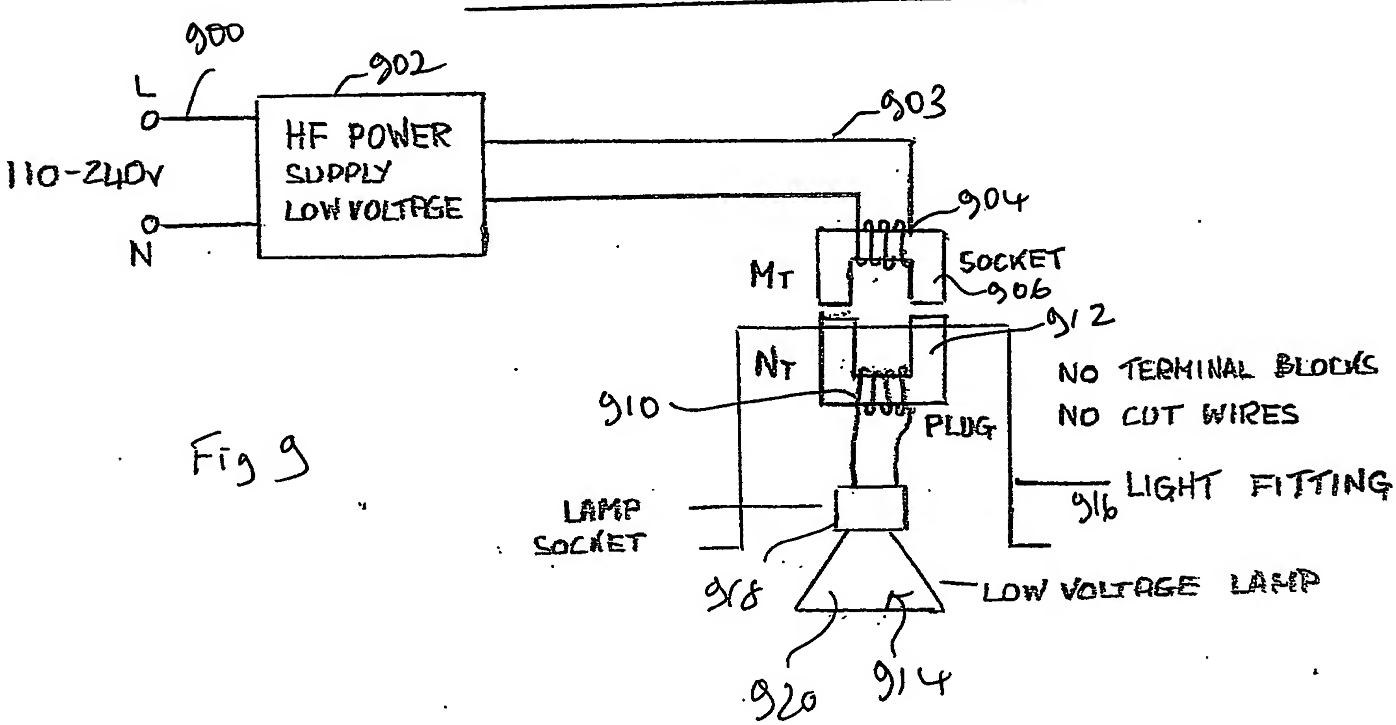


Fig 9

INTEGRATED INDUCTRONICS
CONNECTOR TO POWER SUPPLY

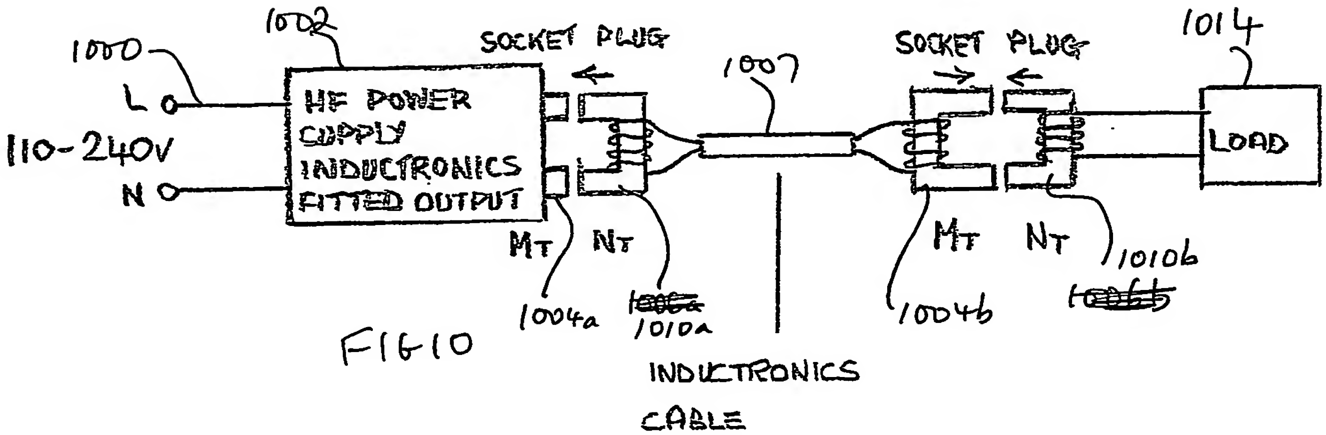


FIG10

EXAMPLE LIGHTING SYSTEM
USING INDUCTRONICS CONNECTORS

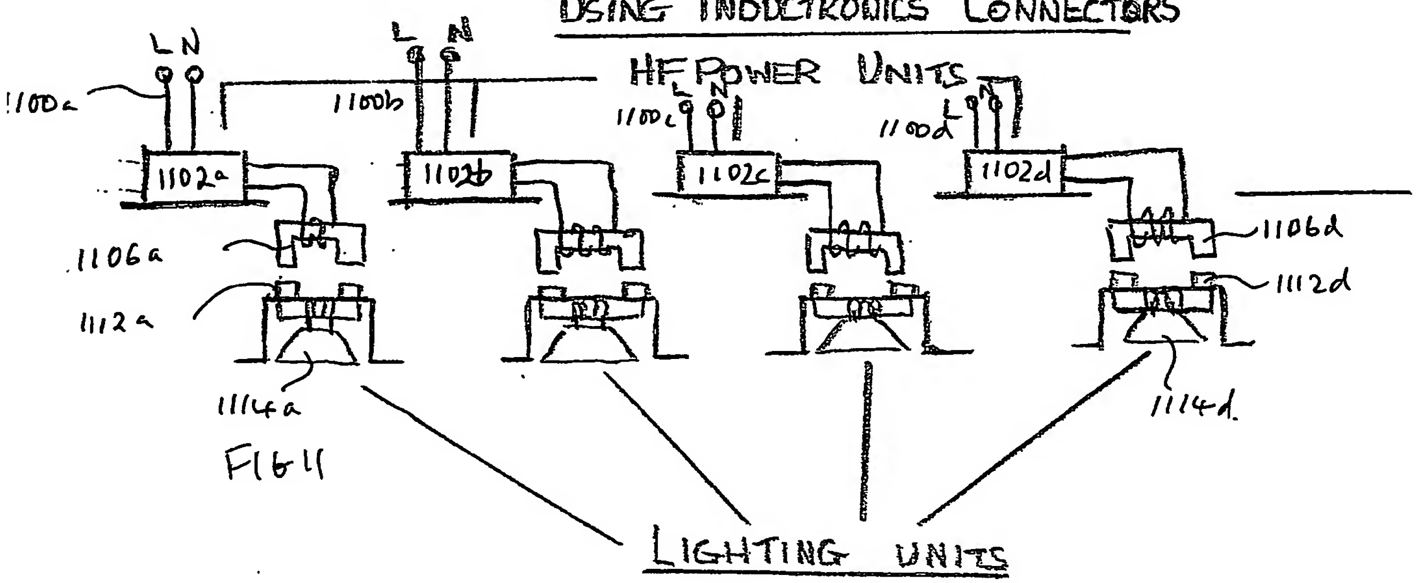


FIG11

NO CUT WIRES
WIRE LOOPS THROUGH CEILING
NO TERMINAL BLOCKS
REMOVE OR INSTALL LIGHTING UNITS SIMPLY (NO WIRES OR TERMINAL

INDUCTRONIC SERIES SYSTEMS

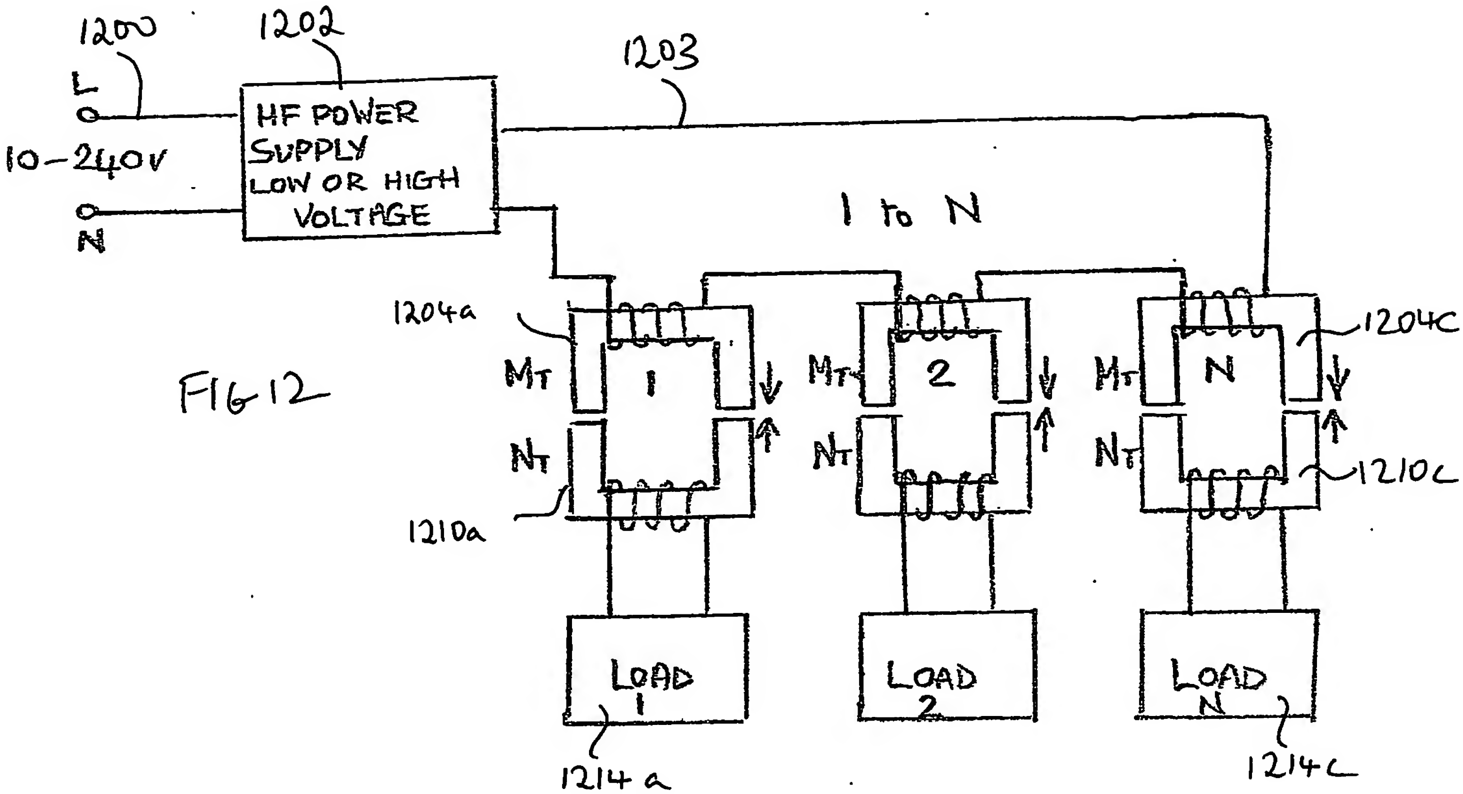


FIG 12

INDUCTRONIC PARALLEL SYSTEMS

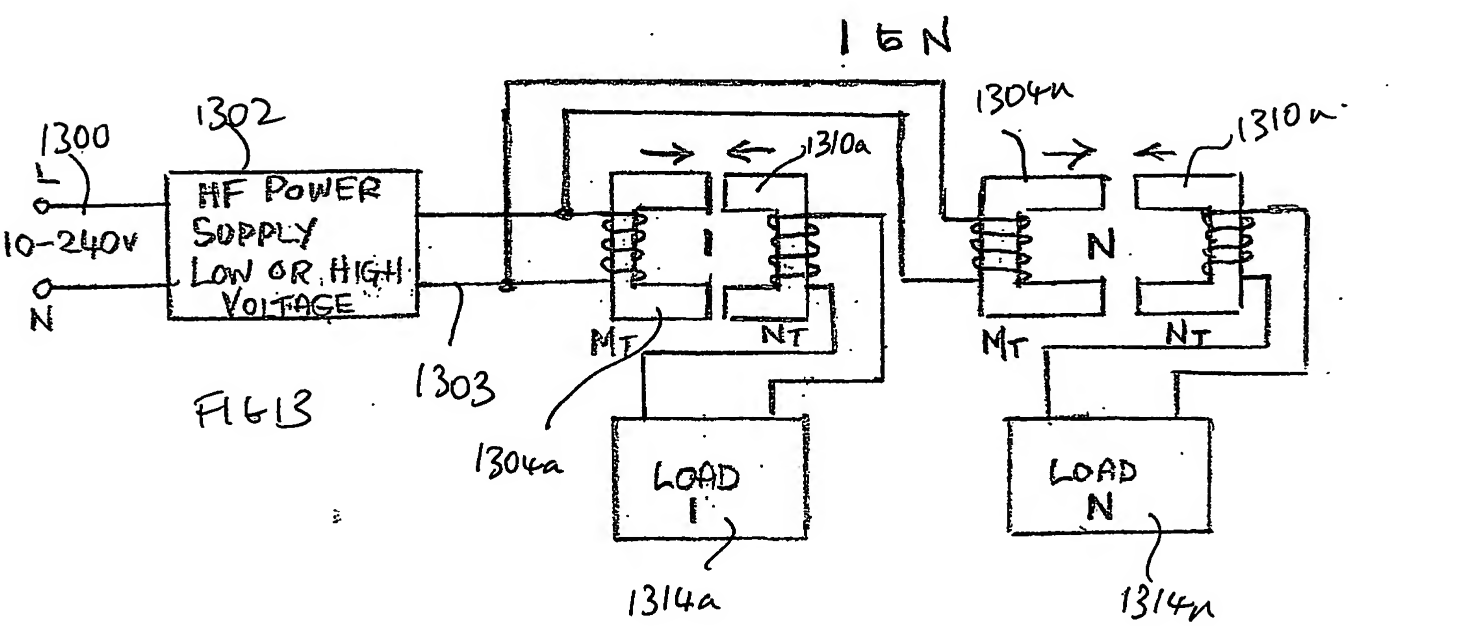
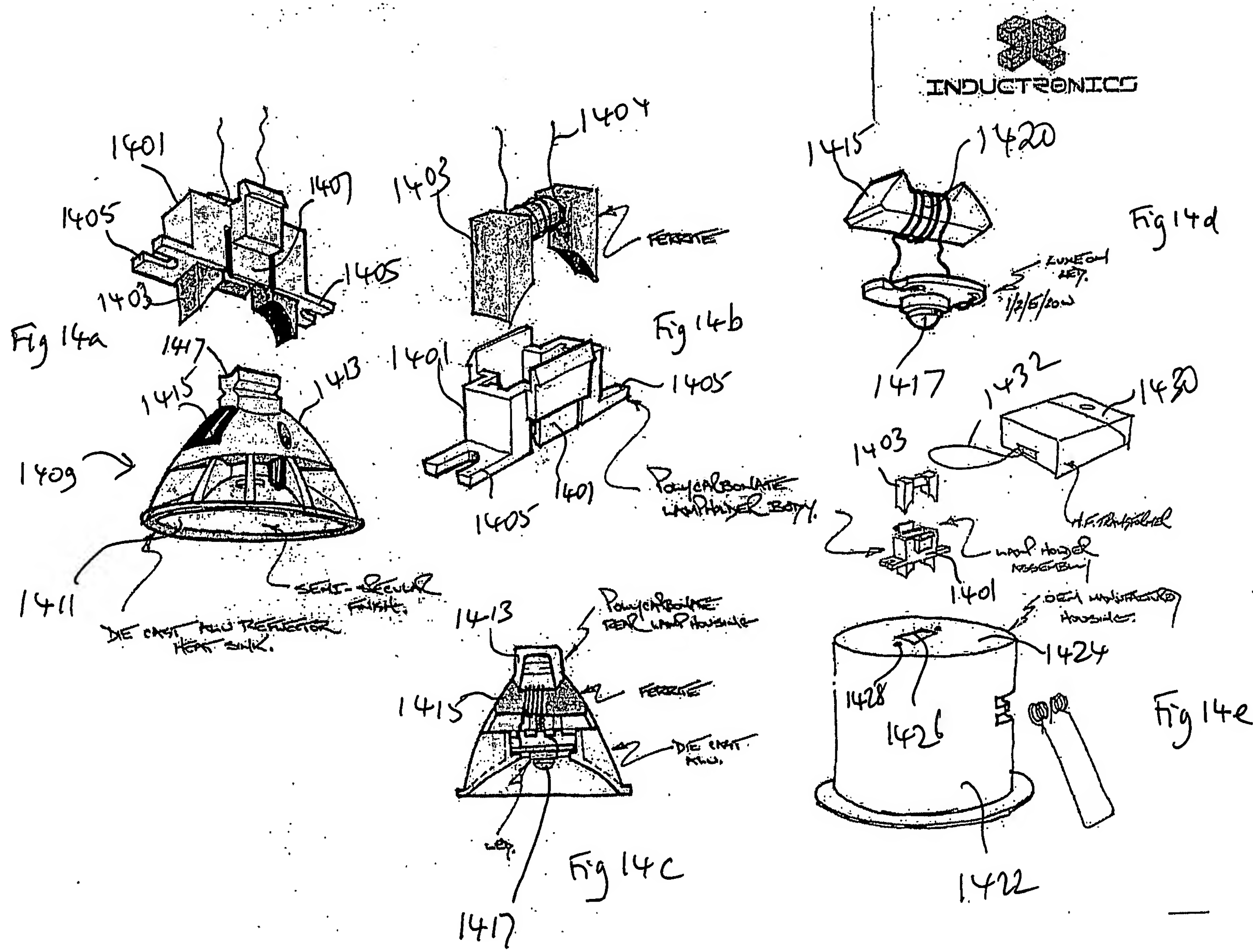


FIG 13


INDUCTRONICS
1401
1405
1407
1403
1405
Fig 14a
1417
1415
1413
1409
1411
DIE CAST ALU REFLECTOR HEAT SINK.
SEMI-SPECULAR FINISH.
1404
1403
FERRITE
Fig 14b
1401
1405
1405
1401
POLYCARBONATE LAMPHOLDER BODY.
1413
POLYCARBONATE REAR LAMP HOUSING
1415
FERRITE
DIE CAST ALU.
LED.
Fig 14C
1417
1415
1420
Fig 14d
LUXEON REF.
1417
1432
1430
1403
H.F. TRANSFORMER
LAMP HOLDER ASSEMBLY
1401
OEM MANUFACTURED HOUSING.
1424
1428
1426
Fig 14e
1422

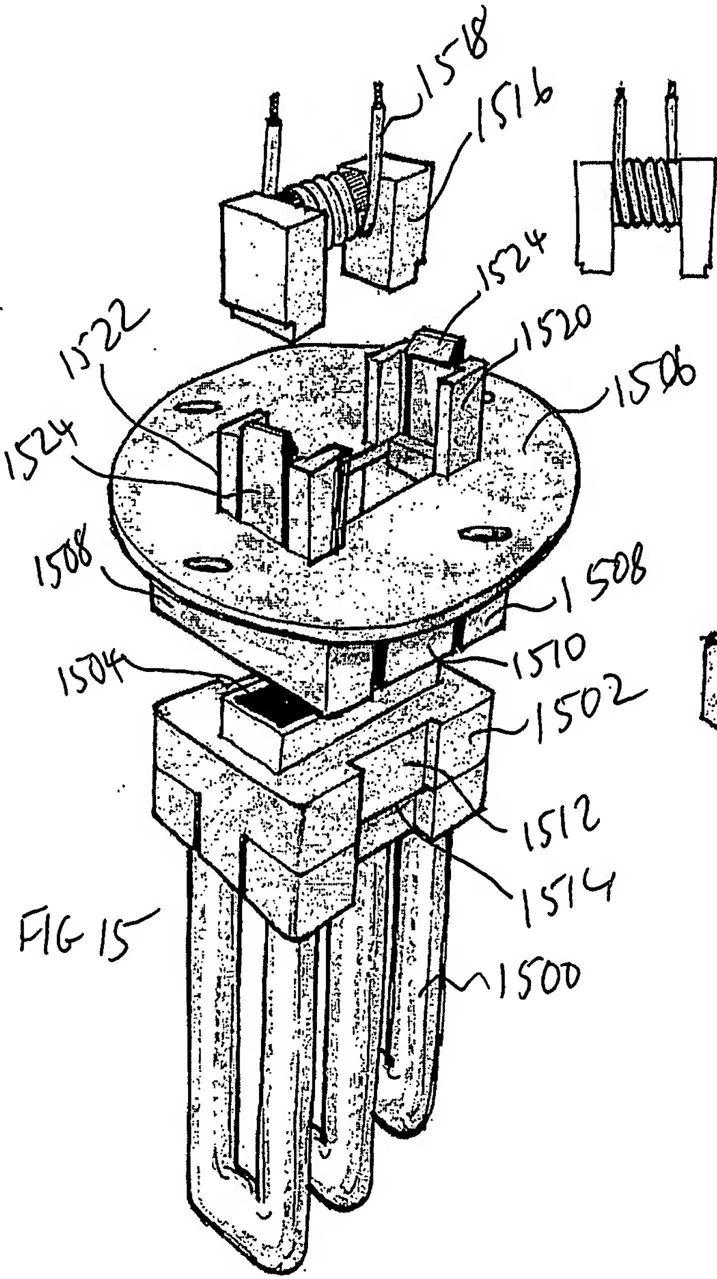


FIG 15

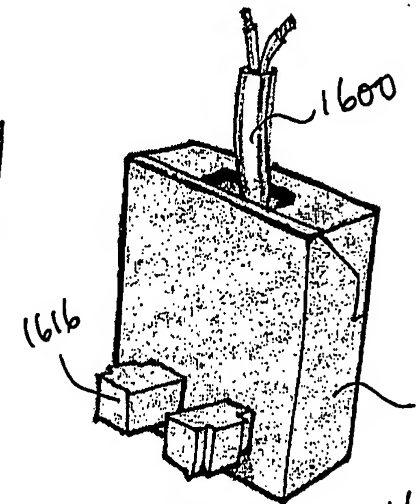


Fig 16a

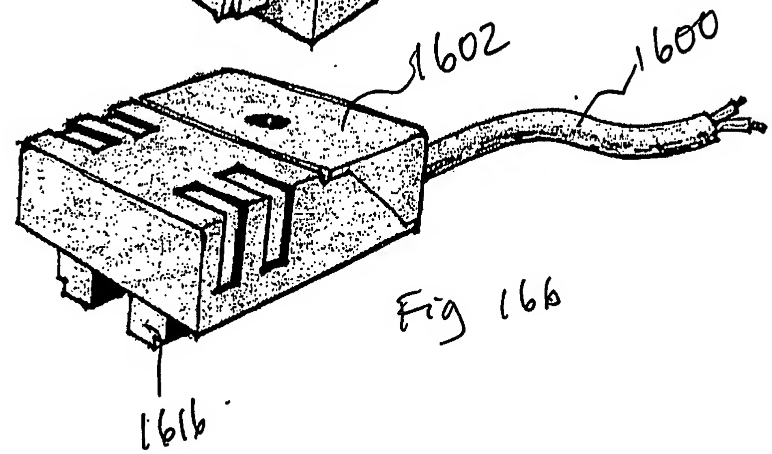
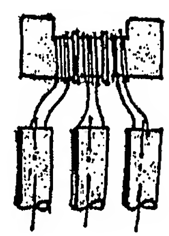


Fig 16b



INDUCTRONICS

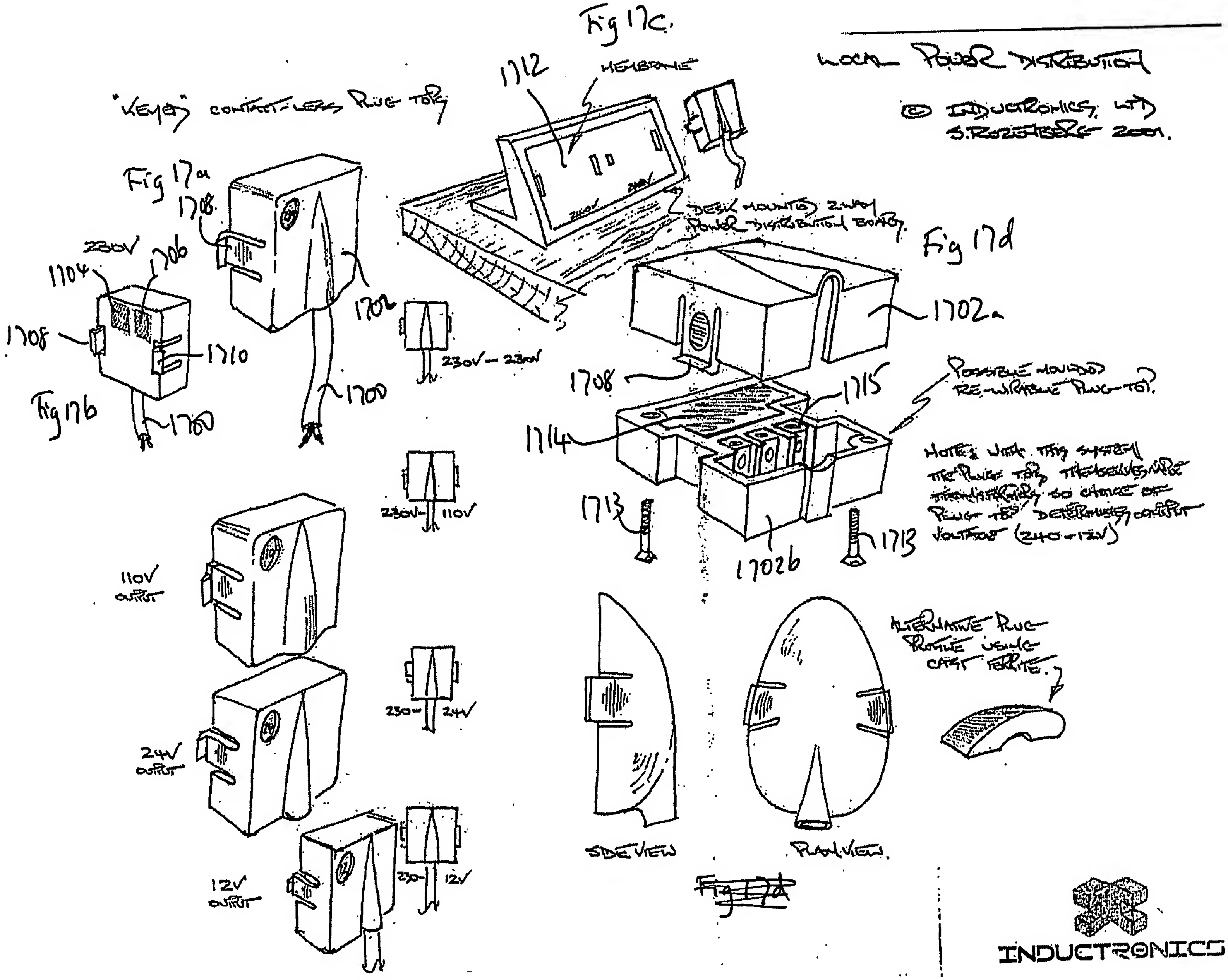

LOCAL POWER DISTRIBUTION
© INDUCTRONICS LTD
S.ROZENBERG 2001.
"KEYED" CONTACT-LESS PLUG TOP
Fig 17a
Fig 17b
Fig 17c
Fig 17d
1700
1702
1702a
1702b
1704
1706
1708
1710
1712
1713
1714
1715
230V
MEMBRANE
DESK MOUNTED 2WAY POWER DISTRIBUTION BOARD
230V — 230V
230V — 110V
230 — 24V
230 — 12V
110V OUTPUT
24V OUTPUT
12V OUTPUT
POSSIBLE MOULDED RE-WIRABLE PLUG-TOP.
NOTE: WITH THIS SYSTEM THE PLUG TOPS THEMSELVES ARE TRANSFORMERS SO CHOICE OF PLUG TOP DETERMINES OUTPUT VOLTAGE (240→12V)
ALTERNATIVE PLUG PROFILE USING CAST FERRITE.
SIDE VIEW
PLAN VIEW
INDUCTRONICS

Fig 18a

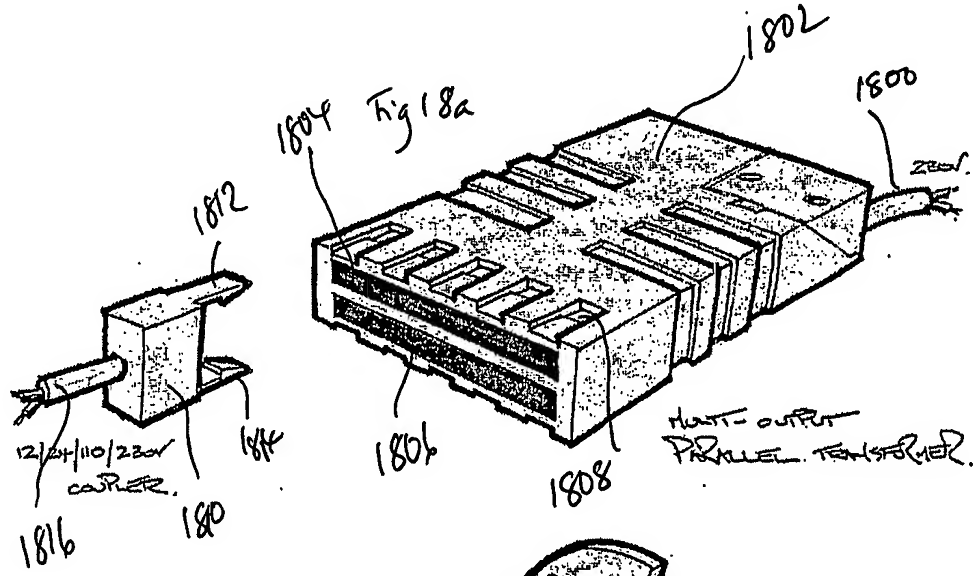


Fig 18b

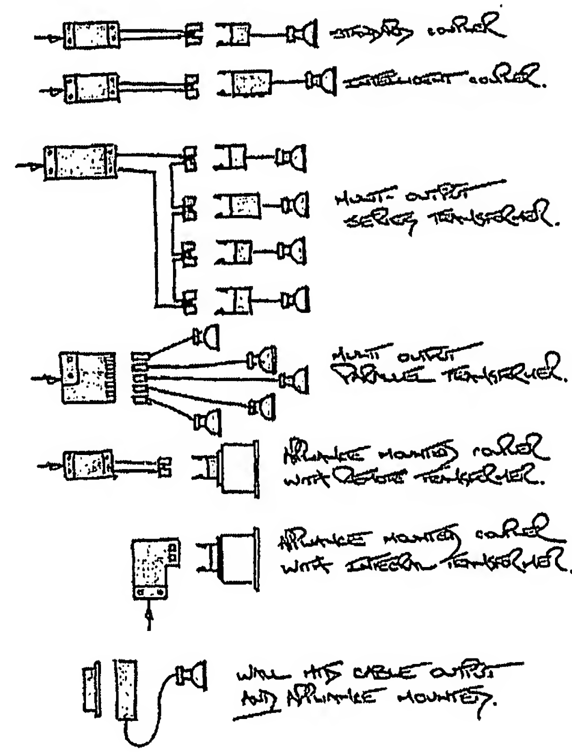
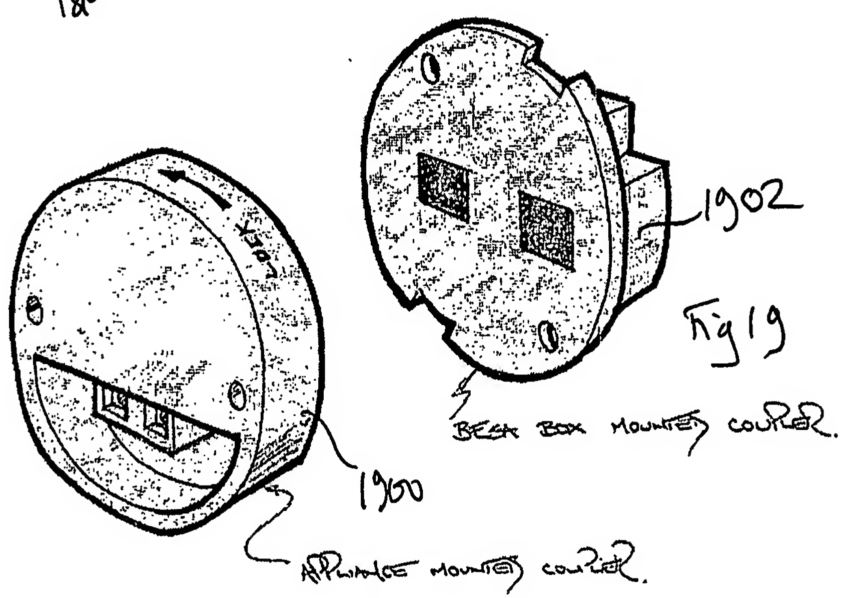


Fig 19



INDUCTRONICS

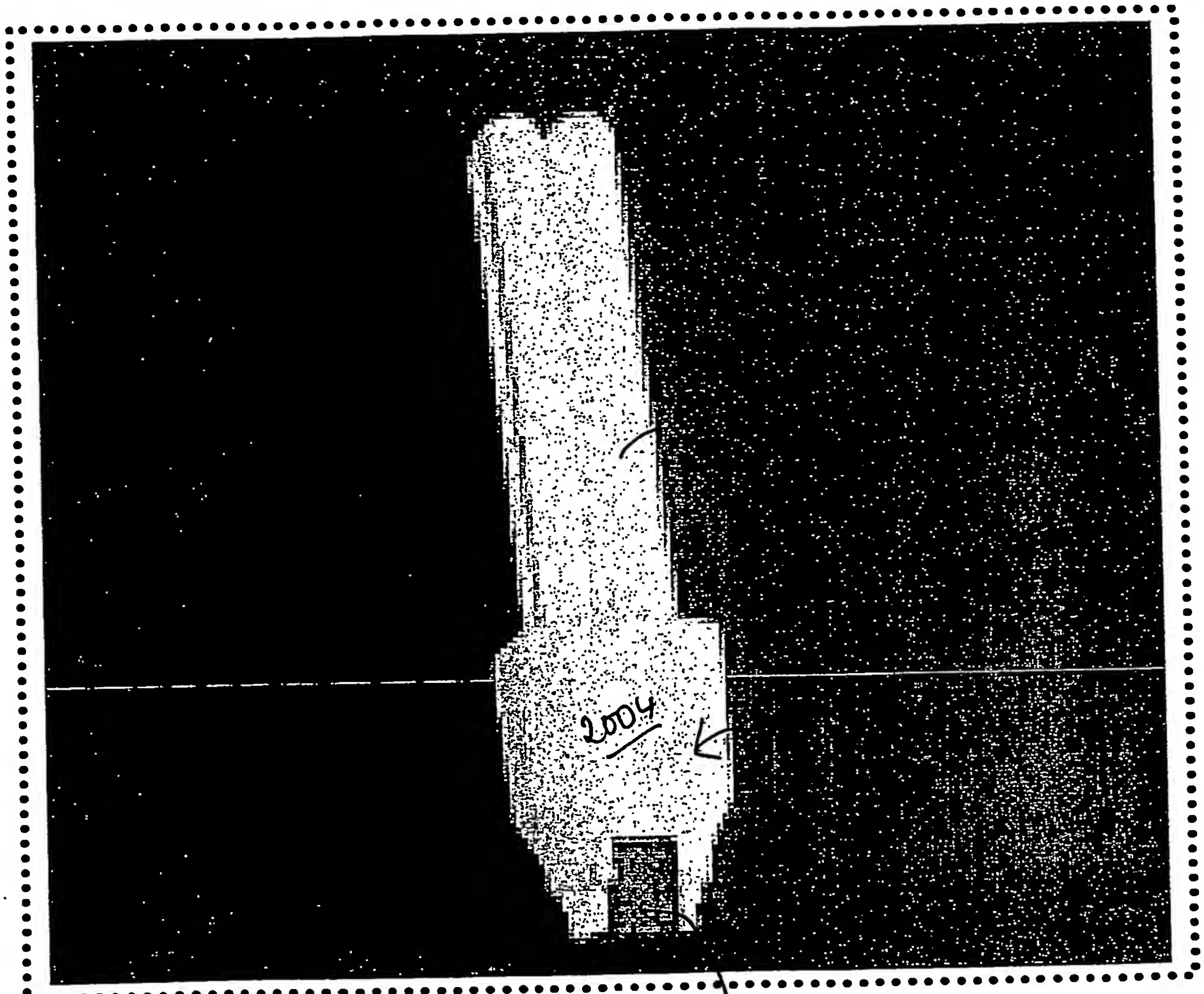


Fig 20

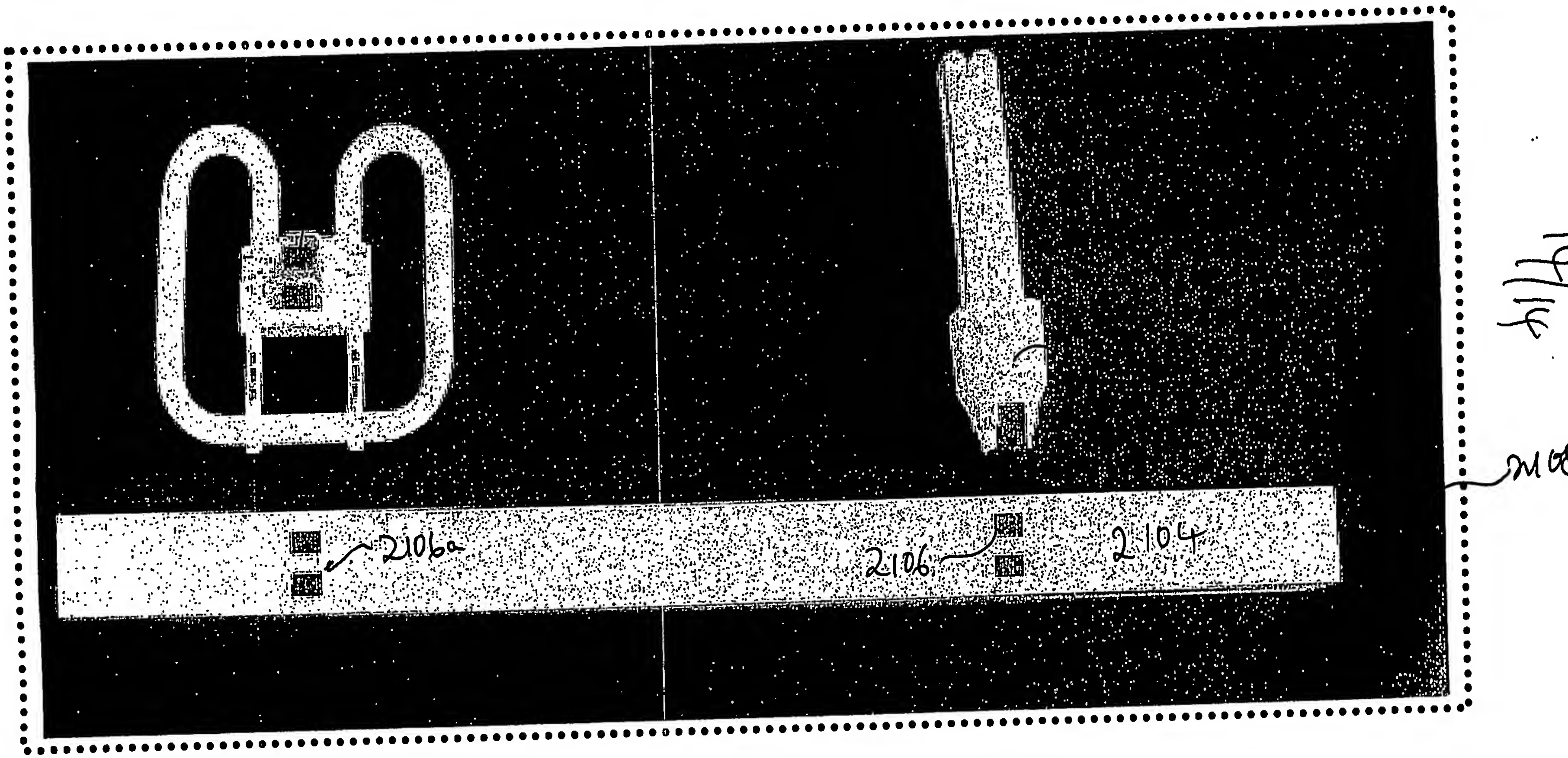


Fig 21